10/569848
Amendment Under PCT Article 34
Dated 28.01.2005
IAP20 Rec'd PCT/PTO 27 FEB 2006

manufactured product. Subsequently, the wire material is trimmed in accordance with a predetermined product shape. This forms an engaging means with an engaging projection and recess on a frictional contact surface of the body, and the frictional contact surface of the body becomes dimpled.

It can easily be understood that when using a wide band, which can be expected to have higher output, there may be greater unevenness in contact pressure on the arcuate band holding surface in the widthwise direction of the band. (For example, refer to the bottom right column of Japanese Laid-Open Patent Publication No. 58-50139.)

In order to eliminate these problems, Japanese Laid-Open Patent Publication No. 2003-42235 (Patent No. 3559006) (Patent Document 3) describes a metallic belt including a push block substantially similar to those of Patent Documents 1 and 2 and particularly includes a band having two continuous arcuate cross-sections. The band holding surface of the push block is formed to be arcuate in correspondence with the shape of the band. Therefore, the contact pressure of the band on the band holding surface of the push block is uniform. This prevents lateral movement of the band in the width direction at the band holding surface of the push block. In addition, the band is expected to have a longer life since an oil sump is formed between the innermost layer of the band and the band holding surface, as shown in Fig. 3.

According to the results of a vehicle road test using the metallic belt of Patent Document 1, since the push block formed from a single wire block has a smooth arcuate surface that is devoid of sharp angles, much progress has been made

contact surfaces of the body and have an outer surface that is continuous with the side contact surfaces of the body. A pair of opposed hooks extend inwardly from distal ends of the pillars. An opening is defined by the pair of hooks. A band holding surface is formed with a cross-sectional shape of a plurality of arcs arranged in parallel on the body in the opening, with the band inserted in the opening of each push block and held on the band holding surface. A metal retainer is arranged on an outer surface of the band in a manner engageable with the pair of hooks to ensure engagement between the band and the push blocks. A ring is attached to the outer surface of the retainer to prevent deformation of the retainer.

It is desirable that the inner circumferential length of the ring be set 0.5 to 1.0 mm longer than the outer circumferential length of the retainer. It is desirable that the width W2 of the ring and the width W of the opening of the push block have a relationship satisfying $W2 \leq W$. It is preferable that the ring has a plate thickness of 0.15 to 0.25 mm.

It is desirable that sets for projections and concavities for forcing and ensuring alignment of the push blocks that are adjacent be formed at a total of three locations, two on the hooks and one on the body, with each concavity having a shape similar to the corresponding projection.

It is desirable that a corner located at a front side of the body with respect to the travel direction be formed with an obtuse angle (θ) to reduce power transmission loss with the pulleys.

It is desirable that the oil breaking portion be formed by a ridge line defined by the contact surface and the rear surface of the push block.

It is desirable for the front half of the contact surface to form an obtuse angle with the front surface of the push block, and the rear half of the contact surface to form an obtuse angle with the rear surface of the push block. The ridge line functioning as the oil film breaking portion extends along the entire length of the contact surface at a middle part of the contact surface in the widthwise direction.

It is desirable for a step to extend along the entire length of the contact surface on a front portion of the contact surface. The step defines the ridge line functioning an the oil film breaking portion.

It is desirable for a front portion of the contact surface to form an obtuse angle with the front surface of the push block, and a groove to extend along the entire length of the contact surface at the middle of the contact surface. An inner wall of the groove and the contact surface defines the ridge line that functions as the oil film breaking portion. It is desirable for the groove to have a

rectangular cross-section. The groove may have a triangular cross-section.

It is desirable for the contact surface of the push block including the oil film breaking portion for breaking an oil film to have a plurality of grooves extending parallel to the travel direction of the push block.

A further aspect of the present invention that can be expected to have higher output and longer life provides a metallic belt including an endless metal band and a plurality of push blocks engaged with the metal band in a relatively movable manner and wound between a drive pulley and a driven pulley so as to enable continuously variable transmission of rotation speed of the driven pulley. The metal band of the metallic belt including a plurality of thin plate-shaped rings having cross-sections of a plurality of continuous arcs, the rings being superimposed to form the metal band. An outer surface of the metal band is divided into two without using flexibility to form an endless non-processed retainer for engaging the metal band and the push block and an endless non-processed ring for preventing deformation caused by vibration in the superimposing direction of the metal band. The retainer and ring have an arcuate cross-sectional shape similar to the cross-sectional shape of the metal band. The push block includes a body having two outer side surfaces defining side contact surfaces that are inclined to respectively make frictional contact with the pulleys, pillars respectively extending along extensions of the two contact surfaces of the body, a pair of opposed hooks formed on distal ends of the pillars, an opening for insertion of the metal band, and a band holding surface defined on an

Fig. 22 is a cross-sectional view of a conventional metallic belt;

Fig. 23 is a perspective view showing a metallic belt in the prior art;

Fig. 24 is a perspective view showing a push block according to a second embodiment;

Fig. 25(a) is a partial side view showing a push block of this embodiment, and Figs. 25(b), 25(c), 25(d), 25(e), and 25(f) are partial side views each showing modifications of the push block;

Fig. 26a) is a diagram showing a recess groove of the push block of Fig. 25(b), and Fig. 26(b) is a diagram showing the recess groove of the push block of Fig. 25(d);

Fig. 27(a) is an explanatory diagram showing the operation of the push block in the second embodiment, and Fig. 27(b) is an explanatory diagram showing the operation of a push block in the prior art;

Fig. 28(a) is a cross-sectional view of a metallic belt according to a third embodiment, and Fig. 28(b) is a cross-sectional view showing a modification in the cross-sectional shape of the retainer and ring;

Fig. 29(a) is a front view showing a forming state of the push block, and Fig. 29(b) is a side view showing the push block;

Fig. 30(a) is a perspective view showing the metallic belt, and Fig. 30(b) is an explanatory diagram showing the assembly of the metallic belt;

Fig. 31(a) is a plan view showing a state in which the push block is assembled to the metal band, and Fig. 31(b) is a side view showing the same; and

Fig. 32(a) is a perspective view showing a metallic belt having a retainer with a shape differing from that of the retainer of Fig. 30(a), and Fig. 32(b) is an explanatory

In the push block 2 of a second modification shown in Fig. 25(c) and Fig. 26(a), the front half 4b of the side contact surface 4 forms and obtuse angle θ relative to the front surface 2F of the push block 2, and the rear half 4b of the side contact surface 4 forms an obtuse angle θ relative to the rear surface 2B of the push block 2. Accordingly, the ridge line 4a, for breaking up the oil film, extends along the entire length of the side contact surface 4 at the center of the side contact surface 4 in the widthwise direction. The ridge line 4a of the second modification has a function similar to the ridge line 4a of the push block 2 of the second embodiment. Further, the push block 2 of the second modification has a plurality of grooves 4h formed in the side contact surface 4 and extending in the travel direction S. The grooves 4h discharges the residual oil film, broken up by the ridge line 4a, out of the push block 2.

In the push block 2 of a third modification shown in Figs. 25(d) and 26(b), a step β extending along the entire length of the side contact surface 4 is provided at the front of the side contact surface 4. The ridge line 4a formed by the step β is located rearward from the center of the width 4W of the side contact surface 4. The oil film is broken up by the ridge line 4a. In the push block 2 of a third modification shown in Fig. 26(b), a plurality of grooves 4h extending parallel to the travel direction are formed in the side contact surface 4, and the front end of each recess groove 4 is connected to the step β. The residue of the oil film is discharged from the grooves 4 outside the push block 2.

In the push block 2 of a fourth modification shown in Fig. 25(e), the front half 4b of the side contact surface 4 forms and obtuse angle θ relative to the front surface 2F of the push block. A groove 4e having a rectangular cross-section and extending along the entire length of the side contact surface 4 is formed in the center of the side

The structure for achieving efficient power transmission is a simple structure that does not increase the number of components and is realized by simply machining the side contact surfaces 4 on the two sides of the push block 2 to form steps and the like. Since the ridge line 4a for breaking up the oil film OF is formed along the entire length of the side contact surfaces 4, there is no premature wear, and superior durability is obtained.

A third embodiment of the present invention will now be described with reference to Figs. 28(a) and 28(b) to Figs. 32(a) and 32(b) centering on parts differing from the first embodiment.

Although the push block 2 of the present embodiment has a structure similar to the push block of the first embodiment, only the differences in structure are described below. As shown in Figs. 28(a) and 28(b) and Figs. 29(a) and 29(b), four continuous arcuate portions 3u are formed on the band holding surface 3U of the body 3 of the push block 2. The number of the arcuate portions 3u is not limited to four, insofar as the number is a plurality. The arcuate portions 3u extend along the widthwise direction of the push block 2, and are defined by arcs having different centers. The arcuate portions 3u are continuous in an undulated manner.

A retainer 12 is endless and formed from a non-processed material that does not have a through hole. A ring 13 has a width differing from the retainer 12 but is similar to the retainer 12 in that it is endless and formed from a non-processed material that does not have a through hole.

A metal band 11 is formed by a plurality of endless thin-plate rings 11a, and a plurality of arcuate portions 11b are continuously formed along the widthwise direction on the rings 11a in correspondence with the arcuate portions 3u of the push block 2. The arcuate portions 11b of the ring 11a are set so as to have a larger radius of curvature than the arcuate portions 3u of the push block 2.

As shown in Figs. 28(a) and (b), Figs. 30(a) and (b), and Figs. 32(a) and (b), the retainer 12 includes two retainer pieces 121 and 122 that are adjacent in the widthwise direction. The retainer pieces 121 and 122 shown in Fig. 28(a) and Figs. 30(a) and (b), have a single peak in the center, and their entirety forms an arcuate cross-section. The retainer pieces 121 and 122 of another example shown in Fig. 28(b) and Figs. 32(a) and (b) each have arcuate portions 12a including two continuous arcs. The retainer 12 has a retainer piece of which entire width that is greater than the width of the opening between the hooks 6 of the push block 2. The opening is used for the insertion of the metal band 11.

As shown in Figs. 30(a) and 30(b), and Figs. 32(a) and 32(b), the ring 13 is superimposed on the outer surface of the retainer 12 so as to extend across the retainer pieces 121 and 122. This suppresses vibrations and deformation in the superimposing direction of the metal band 11 and the two retainer pieces 121 and 122. As shown in Figs. 28(a) and 28(b), the ring 13 has a cross-sectional shape identical to that of the retainer 12. Therefore, the retainer 12 and the ring 13 have a cross-section similar to that of the metal band 11.

The method for assembling the metal band 11 and push block 2 will now be described. First, as shown in Figs. 31(a) and (b), the metal band 11, which is formed by a predetermined number of rings 11a, is pulled down and deformed in the C direction to provide a gap E between the metal band 11 and the retainer 12. Then, opposing side edges 1211 and 1221 of the retainer pieces 121 and 122 are lifted at the middle portion as shown by reference number 120 as if a person holds his or hand together like in a prayer, and the retainer pieces 121 and 122 are elastically deformed using the gap E until the width of the retainer 12 is compressed until its width becomes about the same as the metal band 11.

A plurality of push blocks 2 are pushed upward in the arrow P direction from the inner side of the metal band 11, as shown in Fig. 30(b) and Fig. 32(b), so as to be inserted in the metal band 11. The retainer pieces 121 and 122, the ring 13, and the push block 2 is slid in the arrow S direction to a position adjacent to the side edges 1211 and 1221. The metal band 11 is completed by repeating these operations.

In this embodiment, the two retainer pieces 121 and 122 are deformed in a hands-in-prayer manner to reduce the width of the retainer 12 and assemble the push block 2 to the metal band 11. Therefore, there is no need to provide a through hole in the retainer 12. Further, since the method of reducing the retainer width and assembling the push block 2 to the metal band 11 is used, there is no concern of the retainer 12 cracking at the origin point of the through hole.

Since the metal band 11 has a cross-sectional shape of a plurality of continuous arcs, the amount of deformation of the metal band 11 is limited. This minimizes the amplitude of the vibration of the metal band 11 arising from the impact of the metal band 11 and the push block 2 at the inflection point where the pulley circular path changes to the inter-pulley linear path. Particularly since a non-processed ring that does not have a through hole may be used as the retainer 12, which functions to engage with the push block 2, there is no concern for cracking occurring in the retainer 12, as previously described.

Since a metal wire material is used as the material of the push block 2 in the present embodiment, the push block 2 has a smooth exterior surface. Therefore, concentration of stress at the contact point between the metal band 11 and the push block 2 is suppressed, and the metal band 11 has a prolonged life.

The cross-sectional shape of the band holding surface 3U of the push block 2 has a shape that is optimal for the cross-sectional shape of the metal band 11, that is, a cross-sectional shape of a plurality of continuous arcs. Further, if the radii of curvature of the arcs of the installation surface 3U are greater than the radii of curvature of the arcs of the metal band 11, the metal band 11 and push block 2 have similar shapes and correspond with one another at the plurality of continuous arc parts. Since the radii of curvature of the arc shapes of the push block 2 is greater than the radii of curvature of the arc shapes of the metal band 11, a crescent-shaped gap is formed between adjacent arcs along the superimposing direction of the push

block 2 and metal band 11. This holds lubricating oil in the gap. Thus, it is easy to supply lubricating oil between the push block 2 and the metal band 11 near the inflection point where the pulley circular path changes to the inter-pulley linear path.

The present invention is not limited to the above embodiments, and may also be realized as described below.

A steel plate may be used in place of the metal wire material to fabricate the push block 2 of the third embodiment. Since the push blocks actually used presently in the world are made of 100% steel, when using steel plates, there should be no resistance to the handling and such push block would become popular faster.

The retainers 121 and 122 and the ring 13 may all be formed from the same type of member.